PATENT ABSTRACTS OF JAPAN

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NIPPON ESUTETSUKU:KK

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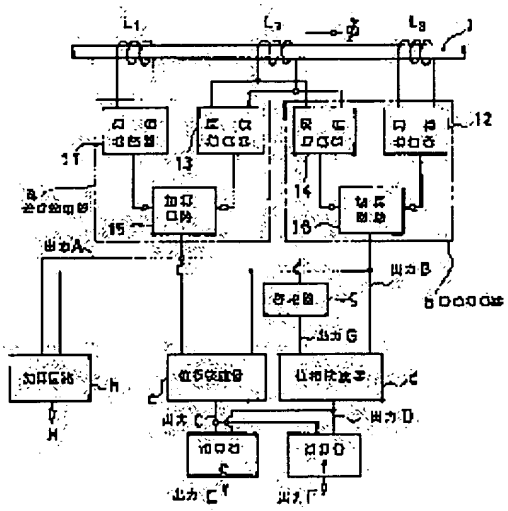
UENO AKIO

(54) MAGNETIC FLUX LEAKAGE FLOW DETECTOR

(57)Abstract:

PURPOSE: To improve the S/N of a detector and constitute the detector to have an easily adjustable simple structure by detecting the phases of the output signals of two or more differential circuits respectively composed of pairs of adjacent detection coils in such a way that one of the phases is detected through a phase shifter and the other phase is directly detected.



CONSTITUTION: A material 1 to be inspected is run through detection coils L1-L3 coaxially arranged in series in parallel to the direction of a magnetic field. In-phase amplifiers 11 and 12 and inverting amplifiers 13 and 14 respectively amplify the outputs of the coils L1,3 and L2 and adder circuits 15 and 16 input the amplified outputs. The circuit 15 and 16 respectively form differential amplifiers (a) and (b) and output A and B. An output G obtained by shifting (g) the phase of the output A and the output B are inputted to a phase detector (d) and the outputs A and B are inputted as they are to another phase detector (c). The outputs C and D of the detectors (c) and (D) are outputted as outputs E and F after addition (e) and subtraction (f). At the time of outputting the outputs E and F, the S/N can be remarkably improved when the noise contained in the output F is minimized by adjusting the phase shifter (g) so that the output E can become the maximum.

LEGAL STATUS

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[Date of registration]	29.06.2001
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[Date of requesting appeal against examiner's decision of rejection]	
[Date of extinction of right]	29.06.2004

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CLAIMS

[Claim(s)]
[Claim 1] In the leakage magnetic-field test equipment which the sensing coil arranged so that a shaft may become parallel to this field is penetrated, and said shaft orientation is run flaw detection-ed material, and detects the abnormalities of said flaw detection-ed material in a quiescence field based on the electromotive force of said coil At least three sensing coils arranged along the die-length direction of said flaw detection-ed material, For another side, one side is leakage magnetic-field test equipment which has two or more differential circuits which make the sensing coil of two ****** one pair among these sensing coils, and is characterized by inputting directly the output signal of each of this differential circuit into a phase detector, and carrying out phase detection through a phase-shifting circuit.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the suitable leakage magnetic-field test equipment for a magnetic or nonmagnetic conductive wire rod and a bar.
[0002]
[Description of the Prior Art] Also in production processes, such as a wire rod and a bar, a defect arises in these front faces and interior according to various causes. As equipment which detects a defect in-line one or on-line automatically, conventionally The ultrasonic test equipment which introduces a supersonic wave into the interior of the charge of inspected material, and detects a defect from the condition of this reflected wave, The eddy current test equipment which alternating field are made to act on the charge of inspected material, is made to generate an eddy current in this ingredient, and detects a defect from the situation of this eddy current, Place a sensing coil into a quiescence field, it is made to run a specimen in the sensing coil, and there is leakage magnetic-field test equipment which detects a defect from the electromotive force by this coil cutting the magnetic leakage flux by the defect. Among these, from flaw detection being possible at high speed, eddy current test equipment and leakage magnetic-field test equipment are used widely, and are properly used according to conditions, such as a defect's existence part and a gestalt. Among these, an SN ratio tends to get worse under the effect by the vibration of an ingredient in the case of carrying out flaw detection at high speed, and especially leakage magnetic-field test equipment has the problem that highly precise flaw detection is not made.
[0003] JP,61-292548,A is related with JP,57-60258,A solving the problem of a fall of a S/N ratio based on the above-mentioned vibration in the magnetic foreign body detection equipment in the copper-wire material using the leakage MAG of this application and law of identity, respectively in eddy current test equipment. Each proposal of these two affairs receives a part for the noise of a low frequency. For example, as shown in drawing 1 , keep spacing in the shaft orientations of opposite Perilla frutescens (L.) Britton var. crispa (Thunb.) Decne., and two or more sensing coils are arranged on the flaw detection-ed material 1. The signal from each coil was combined with the differential amplifier etc., it is the method which decreases the component of the noise signal by vibration etc., and it is a means effective in performing highly precise flaw detection at high speed, and, as for this method, the equipment of this invention also uses this technique. However, the offset approach of the low-frequency component by this differential results in suiting in slight strength on the contrary by the signals from which a phase becomes reverse mutually. As opposed to the noise of a high frequency moreover, said JP,57-60258,A Mutually [three sensing coils arranged by ******** on the 1 shaft] The inside of two ******, Reverse the output of one coil and two arithmetic circuits (13 16) which add this with the output of another side are prepared. Moreover, said two circuits (26 27) which extract the component more than predetermined frequency respectively, add each other among the reversal output of one coil and the output of the coil of another side among the coils of two ******, and are reversed are prepared, and these two outputs and two outputs of said arithmetic circuit are added. However, equipment is complicated and, as for the above-mentioned equipment, the handling of adjustment etc. also has the fault which is not easy.
[0004]
[Problem(s) to be Solved by the Invention] This invention is comparatively simple in equipment, and also aims adjustment at offering easy leakage magnetic-field test equipment.
[0005]
[Means for Solving the Problem] In the leakage magnetic-field test equipment which this invention penetrates the sensing coil arranged in a quiescence field so that a shaft may become parallel to this field, runs said shaft orientation flaw detection-ed material, and detects the abnormalities of said flaw detection-ed material based on the electromotive

force of said coil At least three sensing coils arranged along the die-length direction of said flaw detection-ed material, It is leakage magnetic-field test equipment characterized by having two or more differential circuits which make the sensing coil of two ****** one pair among these sensing coils, and another side inputting and carrying out phase detection of the output signal of each of this differential circuit to a phase detector directly through a phase-shifting circuit, as for one side.

[0006]

[Function] Although the quiescence field generator which this invention uses for target leakage magnetic-field test equipment is considered so that the magnetic field where a possible limitation is equal (a direction and strength) may be realized, it has come to realize a sufficiently equal magnetic field. For this reason, the eddy current according to that vibration will occur in this ingredient, if **-ed material vibrates all over this magnetic field, according to this eddy current, magnetism occurs, the magnetic flux in a sensing coil will change and an oscillating noise (electrical potential difference) will be generated. The above-mentioned noise shows the large frequency distribution according to vibration which is the cause. Among these, it is as above-mentioned that could offset each other mostly and said two proposals have also adopt this invention by compare with mutual spacing of the sensing coil of the pair arrange by approach, and the noise (therefore, noise of a comparatively low frequency) by the standing wave or progressive wave of sufficiently large wavelength make the sensing coil of a pair this property, and connect these so that the output may serve as differential. Also including the noise reinforced by differential as mentioned above, among differential output components, direct most, level carries out phase-sensitive detection (it is described as phase detection below) of the noise of a specific frequency component, and the noise which is falling the S/N ratio highly, and the description's of this invention improves a S/N ratio. Namely, by acquiring two sorts of signals which carried out offset removal of the noise of a low-frequency component by the above-mentioned differential, and carrying out phase detection of that to which only the suitable phase angle carried out the phase shift of one signal about the above-mentioned specific frequency component among this signal, and the signal of another side For example, therefore, a S/N ratio is improved as cosphi=0 in the phase contrast to the noise of the specific frequency of both signals phi=pi/2, and by carrying out removal attenuation of the noise of this component.

[0007]

[Example] Next, the example of the equipment applied to the flaw detection of steel bar material explains this invention. Drawing 1 is the block diagram of this example, and L1-L3 are sensing coils, and they are arranged so that a shaft may turn into the serial same axle in parallel with the direction of this field, and mutually in the field equipment which was considered and manufactured so that the field phi with a possible equal limitation might be formed in large space and which is not illustrated. It is running to the longitudinal direction with the traveller which inspected material 1 does not illustrate so that these sensing coils L1-L3 may be penetrated. A sensing coil L1 and the output of L3 and L2 are amplified considering a polarity as the same and reverse with the inphase amplifier 11 and 12 and inversed amplifiers 13 and 14, respectively, and each output is inputted into adder circuits 15 and 16. Inphase amplifier, an inversed amplifier and an adder circuit, 11, 13 and 15, and 12, 14 and 16 form the differential-amplifier a row b, respectively, and offset removal of each output A and B is carried out here in a part for the low frequency noise between L1 and L2 and between L2 and L3, respectively. The outputs A and B of differential amplifier a and b are inputted into an adder circuit h as they are, are amplified suitably, and are considered as an output H. It is the same as that of conventional equipment, and with conventional equipment, the above led this output H to the suitable display etc., and uses it for the defect display etc. With the equipment of this invention, it has the next configuration other than the above configuration. A kind of the output of two or more differential amplifier is led to a phase shifter g, phase shift actuation is performed, and phase detection of other outputs which do not carry out a phase to this phase shift output is carried out. That is, in the example, phase shift actuation of the output A was carried out with the phase shifter g, and the output G and output B of another side remain as it is, and are inputted into the phase detector d. Moreover, the outputs A and B of both differential amplifier are inputted into the phase detector c as they are. The outputs C and D of a phase detector are inputted into Adder e and Subtractor f, and each processing is performed to them, and they are considered as outputs E and F.

[0008] Next, drawing 2 describes actuation about the signal by the defect. If inspected material 1 has a minute defect now and this defective part considers as under approach from a left L1, in L1, the induction electromotive force k of one of positive/negative will occur. After this, if a ** defective part passes L1 and keeps away, in L1, the induction electromotive force l with reverse k and polarity will occur. At this time of day, this defective part is approaching the following coil L2, k and k' of like-pole nature follow L2, and l' occurs, respectively. The defective part of the **-ed material 1 of t1 and t2 is the time amount of L1, L2, and L2 and L3 required for passing through between centers, respectively here, respectively. The output of L2 is reversed as shown in -L2 with inversed amplifiers 13 and 14, and it

is adder circuits 15 and 16, and this reversal output is added with L1 and L3, respectively, and serves as a wave shown by L1-L2 (it is the same as an output A), and -L2+L3 (it is the same as an output B). By [this] carrying out reversal addition, offset removal of the part for the low frequency noise to accompany is carried out. Outputs A and B are added like conventional equipment, and turn into an output (L1-2L2+L3) H. Next, a phase shifter is described. Drawing 3 is drawing showing the example of the phase-shifting circuit by L and R, and its vector, and the vector EL of the electrical potential difference eL of the both ends of L is behind only in phi to ES to the vector ES of supply voltage eS. This phi can change to about 0 - pi/2 (90 degrees) to a specific frequency by changing an R value. A phase machine can be made into various formats for the purpose, such as what uses other C (capacity) of this example. Next, a phase detector is described. A phase detector is a wave detector which obtains the output which is proportional to cosphi to the alternating current [as / whose phase contrast is phi on this frequency] V to the alternating current VO of criteria. Among outputs A and B, the signal by the defect becomes settled with the travel speed v of processed material, and mutual spacing of sensing coils L1, L2, and L3 so that drawing 2 may show. Therefore, adjustment of a phase shifter g can be performed by giving aim so that the signal by the defect may not fall extremely with an output D. With the equipment of this example, the noise under output F of Subtractor f can be made into min by adjusting a phase shifter so that the output E of Adder e may serve as max by drawing 1 . Therefore, the equipment of a defect display and others can be used with an output F. In above equipment, the S/N ratio of an output F was able to be compared with it in an output H, and it was able to improve ten to 12 times.

[0009]

[Effect of the Invention] As stated above, this invention is [that what is necessary is to be the comparatively simple configuration of only adding a phase shifter and a phase detector to conventional equipment, and to make a phase detector into two pieces, to add an adder and a subtractor to this, and just to operate a phase shifter like this operation so that one output may serve as max] very easy handling fundamentally. And since effectiveness can be made into about 10 times compared with the conventional S/N ratio, it improves the usefulness of leakage magnetic-field test equipment further, such as accelerating processing speed more.

[Translation done.]

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TECHNICAL FIELD

[Industrial Application] This invention relates to the suitable leakage magnetic-field test equipment for a magnetic or nonmagnetic conductive wire rod and a bar.

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PRIOR ART

[Description of the Prior Art] Also in production processes, such as a wire rod and a bar, a defect arises in these front faces and interior according to various causes. As equipment which detects a defect in-line one or on-line automatically, conventionally The ultrasonic test equipment which introduces a supersonic wave into the interior of the charge of inspected material, and detects a defect from the condition of this reflected wave, The eddy current test equipment which alternating field are made to act on the charge of inspected material, is made to generate an eddy current in this ingredient, and detects a defect from the situation of this eddy current, Place a sensing coil into a quiescence field, it is made to run a specimen in the sensing coil, and there is leakage magnetic-field test equipment which detects a defect from the electromotive force by this coil cutting the magnetic leakage flux by the defect. Among these, from flaw detection being possible at high speed, eddy current test equipment and leakage magnetic-field test equipment are used widely, and are properly used according to conditions, such as a defect's existence part and a gestalt. Among these, an SN ratio tends to get worse under the effect by the vibration of an ingredient in the case of carrying out flaw detection at high speed, and especially leakage magnetic-field test equipment has the problem that highly precise flaw detection is not made.
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EFFECT OF THE INVENTION

[Effect of the Invention] As stated above, this invention is [that what is necessary is to be the comparatively simple configuration of only adding a phase shifter and a phase detector to conventional equipment, and to make a phase detector into two pieces, to add an adder and a subtractor to this, and just to operate a phase shifter like this operation so that one output may serve as max] very easy handling fundamentally. And since effectiveness can be made into about 10 times compared with the conventional S/N ratio, it improves the usefulness of leakage magnetic-field test equipment further, such as accelerating processing speed more.

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TECHNICAL PROBLEM

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MEANS

[Means for Solving the Problem] In the leakage magnetic-field test equipment which this invention penetrates the sensing coil arranged in a quiescence field so that a shaft may become parallel to this field, runs said shaft orientation flaw detection-ed material, and detects the abnormalities of said flaw detection-ed material based on the electromotive force of said coil At least three sensing coils arranged along the die-length direction of said flaw detection-ed material, It is leakage magnetic-field test equipment characterized by having two or more differential circuits which make the sensing coil of two ****** one pair among these sensing coils, and another side inputting and carrying out phase detection of the output signal of each of this differential circuit to a phase detector directly through a phase-shifting circuit, as for one side.

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OPERATION

[Function] Although the quiescence field generator which this invention uses for target leakage magnetic-field test equipment is considered so that the magnetic field where a possible limitation is equal (a direction and strength) may be realized, it has come to realize a sufficiently equal magnetic field. For this reason, the eddy current according to that vibration will occur in this ingredient, if **-ed material vibrates all over this magnetic field, according to this eddy current, magnetism occurs, the magnetic flux in a sensing coil will change and an oscillating noise (electrical potential difference) will be generated. The above-mentioned noise shows the large frequency distribution according to vibration which is the cause. Among these, it is as above-mentioned that could offset each other mostly and said two proposals have also adopt this invention by compare with mutual spacing of the sensing coil of the pair arrange by approach, and the noise (therefore, noise of a comparatively low frequency) by the standing wave or progressive wave of sufficiently large wavelength make the sensing coil of a pair this property, and connect these so that the output may serve as differential. Also including the noise reinforced by differential as mentioned above, among differential output components, direct most, level carries out phase-sensitive detection (it is described as phase detection below) of the noise of a specific frequency component, and the noise which is falling the S/N ratio highly, and the description's of this invention improves a S/N ratio. Namely, by acquiring two sorts of signals which carried out offset removal of the noise of a low-frequency component by the above-mentioned differential, and carrying out phase detection of that to which only the suitable phase angle carried out the phase shift of one signal about the above-mentioned specific frequency component among this signal, and the signal of another side For example, therefore, a S/N ratio is improved as cosphi=0 in the phase contrast to the noise of the specific frequency of both signals phi=pi/2, and by carrying out removal attenuation of the noise of this component.

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EXAMPLE

[Example] Next, the example of the equipment applied to the flaw detection of steel bar material explains this invention. Drawing 1 is the block diagram of this example, and L1-L3 are sensing coils, and they are arranged so that a shaft may turn into the serial same axle in parallel with the direction of this field, and mutually in the field equipment which was considered and manufactured so that the field phi with a possible equal limitation might be formed in large space and which is not illustrated. It is running to the longitudinal direction with the traveller which inspected material 1 does not illustrate so that these sensing coils L1-L3 may be penetrated. A sensing coil L1 and the output of L3 and L2 are amplified considering a polarity as the same and reverse with the inphase amplifier 11 and 12 and inversed amplifiers 13 and 14, respectively, and each output is inputted into adder circuits 15 and 16. Inphase amplifier, an inversed amplifier and an adder circuit, 11, 13 and 15, and 12, 14 and 16 form the differential-amplifier a row b, respectively, and offset removal of each output A and B is carried out here in a part for the low frequency noise between L1 and L2 and between L2 and L3, respectively. The outputs A and B of differential amplifier a and b are inputted into an adder circuit h as they are, are amplified suitably, and are considered as an output H. It is the same as that of conventional equipment, and with conventional equipment, the above led this output H to the suitable display etc., and uses it for the defect display etc. With the equipment of this invention, it has the next configuration other than the above configuration. A kind of the output of two or more differential amplifier is led to a phase shifter g, phase shift actuation is performed, and phase detection of other outputs which do not carry out a phase to this phase shift output is carried out. That is, in the example, phase shift actuation of the output A was carried out with the phase shifter g, and the output G and output B of another side remain as it is, and are inputted into the phase detector d. Moreover, the outputs A and B of both differential amplifier are inputted into the phase detector c as they are. The outputs C and D of a phase detector are inputted into Adder e and Subtractor f, and each processing is performed to them, and they are considered as outputs E and F.

[0008] Next, drawing 2 describes actuation about the signal by the defect. If inspected material 1 has a minute defect now and this defective part considers as under approach from a left L1, in L1, the induction electromotive force k of one of positive/negative will occur. After this, if a ** defective part passes L1 and keeps away, in L1, the induction electromotive force l with reverse k and polarity will occur. At this time of day, this defective part is approaching the following coil L2, k and k' of like-pole nature follow L2, and l' occurs, respectively. The defective part of the **-ed material 1 of t1 and t2 is the time amount of L1, L2, and L2 and L3 required for passing through between centers, respectively here, respectively. The output of L2 is reversed as shown in -L2 with inversed amplifiers 13 and 14, and it is adder circuits 15 and 16, and this reversal output is added with L1 and L3, respectively, and serves as a wave shown by L1-L2 (it is the same as an output A), and -L2+L3 (it is the same as an output B). By [this] carrying out reversal addition, offset removal of the part for the low frequency noise to accompany is carried out. Outputs A and B are added like conventional equipment, and turn into an output (L1-2L2+L3) H. Next, a phase shifter is described. Drawing 3 is drawing showing the example of the phase-shifting circuit by L and R, and its vector, and the vector EL of the electrical potential difference eL of the both ends of L is behind only in phi to ES to the vector ES of supply voltage eS. This phi can change to about 0 - pi/2 (90 degrees) to a specific frequency by changing an R value. A phase machine can be made into various formats for the purpose, such as what uses other C (capacity) of this example. Next, a phase detector is described. A phase detector is a wave detector which obtains the output which is proportional to cosphi to the alternating current [as / whose phase contrast is phi on this frequency] V to the alternating current VO of criteria. Among outputs A and B, the signal by the defect becomes settled with the travel speed v of processed material, and mutual spacing of sensing coils L1, L2, and L3 so that drawing 2 may show. Therefore, adjustment of a phase shifter g can be performed by giving aim so that the signal by the defect may not fall extremely with an output D. With the equipment of this example, the noise under output F of Subtractor f can be made into min by adjusting a phase shifter so

that the output E of Adder e may serve as max by drawing 1 . Therefore, the equipment of a defect display and others can be used with an output F. In above equipment, the S/N ratio of an output F was able to be compared with it in an output H, and it was able to improve ten to 12 times.

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the block diagram of the example of this invention.
[Drawing 2] It is drawing explaining actuation of the example of this invention.
[Drawing 3] It is drawing explaining the phase-shifting device and actuation of an example.
[Description of Notations]
L1, L2, L3 Sensing coil
11 12 Inphase amplifier
13 14 Inversed amplifier
15 16 Adder
a, b Differential amplifier
g Phase shifter
c, d Phase detector
e, h Adder
f Subtractor
A, B, C, D, E, F, G, H; output
eS, eL, eR Electrical potential difference
ES, EL, ER Vector of an electrical potential difference
phi Phase angle
L Inductance
R Resistance

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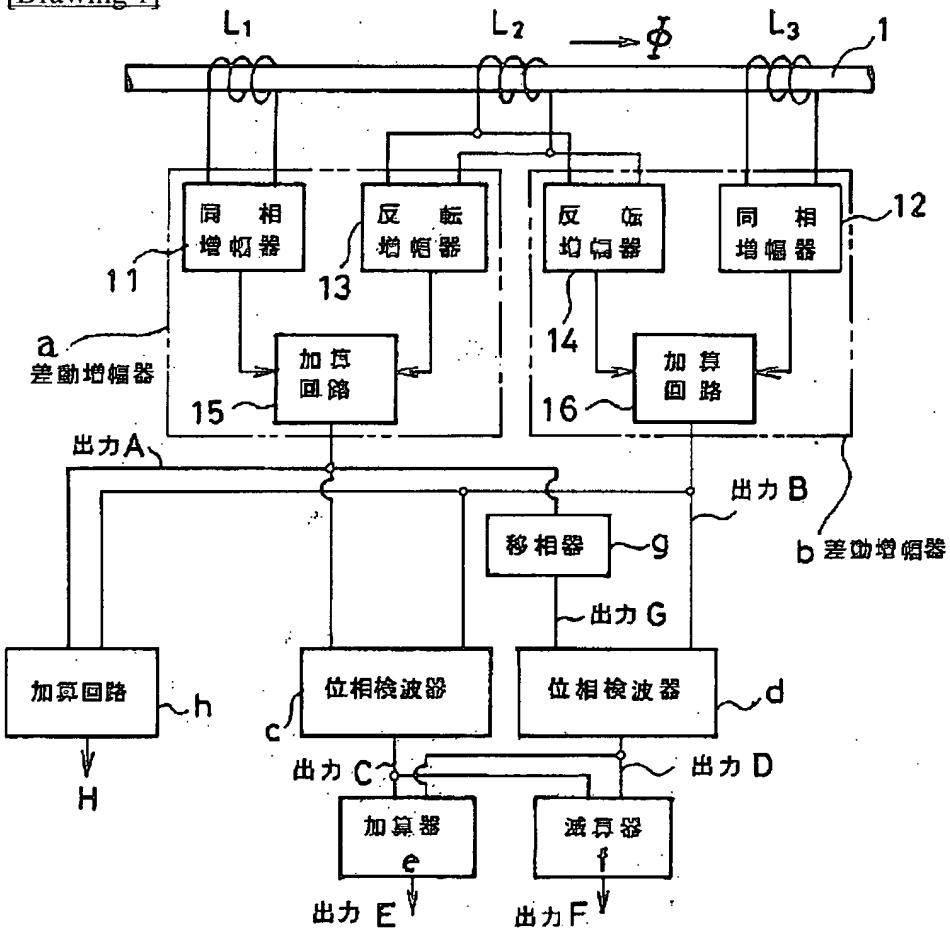
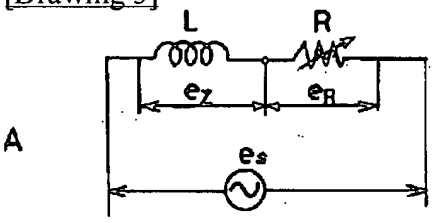
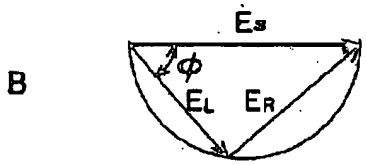
DRAWINGS

[Drawing 1]

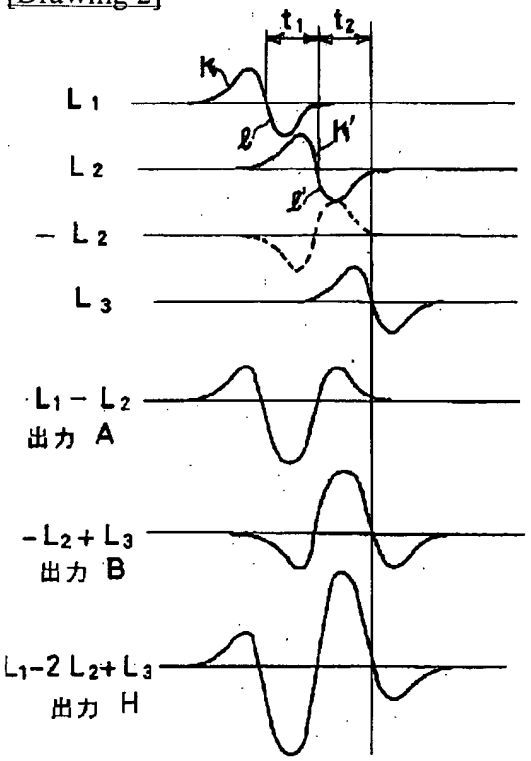


[Drawing 3]





[Drawing 2]



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